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ASTRONOMY EDUCATION RESEARCH: EFFORTS TOWARDS TEACHING FOR DIVERSITY AND INCLUSIVITY IN SOUTH AFRICA

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ABSTRACT

Many students are attracted to astronomy due to its inviting nature of spectacular wonders. However, studying astronomy goes beyond these wonders, which poses a challenge to students knowledge and understanding of basic astronomical phenomena. The University of Cape Town has developed a series of research studies that probe the nature of student difficulties at a fine-grained level, in particular looking into how students conceive of astronomical distances which are beyond immediate human comprehension. The key experimental findings from this study were that as distances increased different modes of thinking were employed to make sense of them. The experimental findings could be explained by the embodied cognition framework which posits that the way we think (all thought) is ultimately grounded in infant sensory-motor experiences. In this case, the thinking template or image schema was suggested to be the "source-path-goal". Having identified the "thinking" framework allows for a research-based construction of learning activities that lead to sense-making. Thus, the notion of the Source-Path-Goal Thinking Template / Image Schema was used to create an activity that would trigger this mode of thinking for large-scale distances. Based on the current experimental findings that can be explained by an "embodied cognition" framework, learning activities were piloted that appear to have had a measure of success.

RESUMEN

Muchos estudiantes se sienten atraídos por la astronomía debido a su naturaleza llamativa llena de maravillas espectaculares. Sin embargo, el estudio de la astronomía va más allá de estas maravillas, lo que supone un reto para el conocimiento y la comprensión de los estudiantes sobre los fenómenos astronómicos básicos. La Universidad de Ciudad del Cabo ha desarrollado una serie de estudios de investigación que examinan la naturaleza de las dificultades de los estudiantes en un nivel muy detallado, en particular, analizando cómo los estudiantes conciben las distancias astronómicas que están más allá de la comprensión humana inmediata. Los hallazgos experimentales claves de este estudio fueron que, a medida que aumentaban las distancias, se emplearon diferentes modos de pensamiento para darles sentido. Los hallazgos experimentales podrían explicarse por el marco de la cognición incorporada que postula que la forma en que pensamos (todo pensamiento) se basa en última instancia en las experiencias sensoriomotoras infantiles. En este caso, se sugirió que la plantilla de pensamiento o esquema de imagen fuera el "origen-camino-objetivo". Haber identificado el marco de "pensamiento" permite una construcción basada en la investigación de actividades de aprendizaje que conducen a la construcción de sentido. Por lo tanto, la noción de plantilla de pensamiento de fuente-ruta-meta/esquema de imagen se utilizó para crear una actividad que activaría este modo de pensamiento para distancias a gran escala. Con base en los hallazgos experimentales actuales que pueden explicarse mediante un marco de "cognición incorporada", se pusieron a prueba actividades de aprendizaje que parecen haber tenido cierto éxito.

Key Words: astronomy education

1. INTRODUCTION

Generally, many students are attracted to astronomy due to its inviting awe and wonder factor. The night sky offers so much richness through the moon, the sun, the stars, and planets are intriguing to people, which later sees young people being interested in becoming astronomers or even astronauts. In the context of the Southern African culture, the night sky is one of the big influencers of storytelling as well as navigation (Venus rising). Through storytelling,

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cultures and larger groups of societies continued to inspire young children to fully enjoy the night sky, as such in modern-day times and technology, this has been more formalized as "astronomy, the study of celestial bodies". Furthermore, this posits astronomy as a mother of all sciences, that open up students interests to many more science areas.

However, students often face difficulties when they have to engage with key astronomical concepts meaningfully, at any level of education (primary school, secondary school, and introductory level at university. Due to the difficulty faced with comprehending astronomical concepts, many students are unable to carry out other astronomy-related tasks. One such difficult concept is the notion of astronomical scales, i.e sizes, and distances. This is one particular pedagogical big idea in astronomy, which the Introductory Astronomy Questionnaire (IAQ) (Rajpaul et al. 2014), showed that this big idea is related to student overall course success.

2. RESEARCH METHODOLOGY

Astronomy Education Research (AER) is a field of study that seeks to investigate the issues that teachers, students, and practitioners have in the teaching and learning of astronomy at all levels. More particularly, the Physics and Astronomy Research group at the University of Cape Town research the extent of student difficulties in order to develop and create an astronomy education research curriculum for inclusivity and diversity.

As first steps, as PhAsER UCT, we probe student knowledge of various aspects in astronomy in order to identify issues that are problematic to student comprehension. In doing so, we develop research instruments that would aid in eliciting student knowledge about different concepts. These research instruments are presented in the form of questionnaires, which are framed as tick-a-box, Force Choice Response, Likert scale or even free written response questions. The framing and context of the questionnaire are the most important factors that we focus on because (i) the way in which we frame questions informs the type of responses we receive, and (ii) the context in which we structure the question to be in, also informs the response. In addition to these aspects, we also include an image of a cartoon character that has no assigned gender, race, ethnicity, age, or hold religious views (Fig. 2). These characters are included so that we are able to get a wide range of answers from different student perspectives.

Q3. [RNKD1]

Order the following by their distance from the Earth's surface. (Write the letter of each item next to the relevant number in the list below):

A = centre of the Milky Way;
B = edge of the observable universe;
C = edge of the Solar System;
D = the moon;
E = the Sun;
F = the nearest star to the sun (Alpha Centauri);
G = the ozone layer;
H = centre of the Earth;
I = Neptune.

Fig. 1. This is an extract of the Distance question ranking task in the Introductory Astronomy Questionnaire (IAQ).

3. RESEARCH INSTRUMENTS

The current research instruments that have been created and used in Astronomy Education Research are; (i) The Introductory Astronomy Questionnaire (IAQ), which was developed in 2014 by Rajpaul et al. (2014, 2018); (ii) Astronomy Questionnaire: Understanding Engagement with Distances, which was developed in 2019 by Makwela (2022). Using the grounded method theory from Charmaz (2006) perspective, we analyze the responses to the research questionnaires (see Fig. 1). The analysis of questions is an iterative process, which is done a couple of times to ensure the trustworthiness of the data.

The research instruments (IAQ) and (AQUED) have produced interesting insights into students thinking. Using these ideas and insights on students thinking, we then create teaching materials, learning interventions that are based on these findings. In doing so, we use student input in creating tools that improve their engagement and understanding of concepts. A great example is seen in Makwela (2022), where the grounded analysis produced a low-level conceptual theory of how students intuitively think about the concept of distance. Then, they used this love-level theory to develop an interventional activity for the students (in the following year, not the same cohort).

We then evaluate the degree of success of the interventional activity as well as the level of engagement. Through the evaluations, we are able to measure how well the activity worked as well as what in the activity did not work. This opens up room for the activities to be modified as seen fit.

This methodology enables us to value student inputs, which allow researchers to frame their teaching interventions that give students the opportunity to

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Fig. 2. This is an example of the no gender, no race, or religion cartoon characters.

engage meaningfully with astronomical concepts. In addition, student input is important in the transformation of learning and teaching astronomy.

4. OVERALL CONCLUSION

The abstract gives insight to a study in astronomy education research that focused on students understanding of the concepts of size and distance. Through the IAQ, the study identified these aspects (size and distance) as key concepts in understanding astronomy, more importantly, they are the precursors of success in the course. Since students showed no improvement in the comprehension of astronomical distances, the AQUED was administered to elicit students basic understanding of distance.

This data was analyzed using the grounded method theory, in which there was an emergence of a low-level theory. This low-level theory showed to be consistent with one theory of cognition, which is embodied cognition, especially with regard to an image schema. One image schema that was consistent with our low-level theory was the source-path-goal. Using this image schema, we developed an intervention activity, which we hoped will simulate a journey to the universe. (This is in a thesis to be submitted at the University of Cape Town).

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